

Lumbar Spine MRI for Low Back Pain: Indications and Yield

Bahman Roudsari^{1,2}
Jeffrey G. Jarvik^{1,2,3,4}

OBJECTIVE. Low back pain is one of the most common causes of physician visits in the United States with an enormous socioeconomic burden. Because of this burden, numerous studies have focused on its diagnosis and management. New technologies have been quickly adopted with the hope that they will improve our understanding of the physiopathology of the disease and assist us in alleviating patients' pain and discomfort. Unfortunately, previous studies have not been able to show that higher utilization of advanced imaging technology is associated with improvements in patient outcome. This article highlights practices that are evidence-based versus those that are common, or heterogeneous, but not supported by existing evidence. We also highlight outstanding areas for further research.

CONCLUSION. Clinicians and researchers should be encouraged to follow standardized practices in accordance with evidence-based medicine guidelines. The use of such guidelines will decrease variation in care, allowing researchers to more easily design and conduct comparative effectiveness studies of diagnostic imaging.

A 42-year-old woman with a history of chronic back pain reported that she has had this pain for 20 years, initially occurring due to training for her work as a law enforcement officer. She stated that the pain is largely lower lumbar and radiates to her legs bilaterally on the left side down to the calf and the right in the upper thigh only. The pain has gotten progressively worse over the years. She noted some bladder and bowel incontinence for the past several months. The bowel incontinence manifests by her noting her underwear to be soiled. She has seen an orthopedic surgeon and has had at least five epidural steroid injections with minimal improvement. She has been on morphine sulfate controlled-release tablets (MS Contin, Purdue Pharma) as well as short-acting morphine for many years, and that keeps her pain at a 4 of 10. She stated that it quickly goes to 10 of 10 with any sort of activity. She has tried methadone in the past without success. She has also tried oxycodone (OxyContin, Purdue Pharma), which has stopped working.

Her medical history is notable for chronic neck pain, chronic knee pain, depression, temporomandibular joint (TMJ) syndrome, and carpal tunnel syndrome. Her past surgical history is notable for TMJ surgery. Her

current medications include fluoxetine 60 mg by mouth (po) daily, morphine sulfate extended-release 60 mg po twice per day, morphine sulfate immediate-release 15 mg four times daily as needed, cyclobenzaprine 20 mg po three times per day, and ibuprofen 800 mg po three times daily as needed.

Her relevant social history includes currently working 6 hours per week as a massage therapist. She cannot work anymore than this because of her back pain. She has been told to stop working altogether and apply for disability but prefers to continue working.

The relevant portions of the physical examination were as follows: There was marked tenderness to palpation throughout cervical, midthoracic, and lower lumbar spine. The straight leg raising test was negative bilaterally. There was pain with all movements. Her lower extremity strength was limited by pain but otherwise appeared normal bilaterally. There was no sensory loss in either the upper or lower extremities bilaterally. Her reflexes were brisk but symmetric throughout upper and lower extremities. Her toes were downgoing bilaterally. Her gait was slowed but normal. Rectal examination revealed normal rectal tone. MRI revealed a disk extrusion at L2–L3 with moderate central canal compression and nerve root crowding (Fig. 1).

Keywords: disk herniation, low back pain, MRI, spinal stenosis, spine metastasis

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¹Department of Radiology, School of Medicine, University of Washington, Seattle, WA.

²Comparative Effectiveness, Cost and Outcomes Research Center, University of Washington, Seattle, WA.

³Department of Neurological Surgery, School of Medicine, University of Washington, Seattle, WA.

⁴Department of Health Services, School of Public Health, University of Washington, Box 359728, 325 Ninth Ave., Seattle, WA 98104-2499. Address correspondence to J. G. Jarvik (jarvikj@u.washington.edu).

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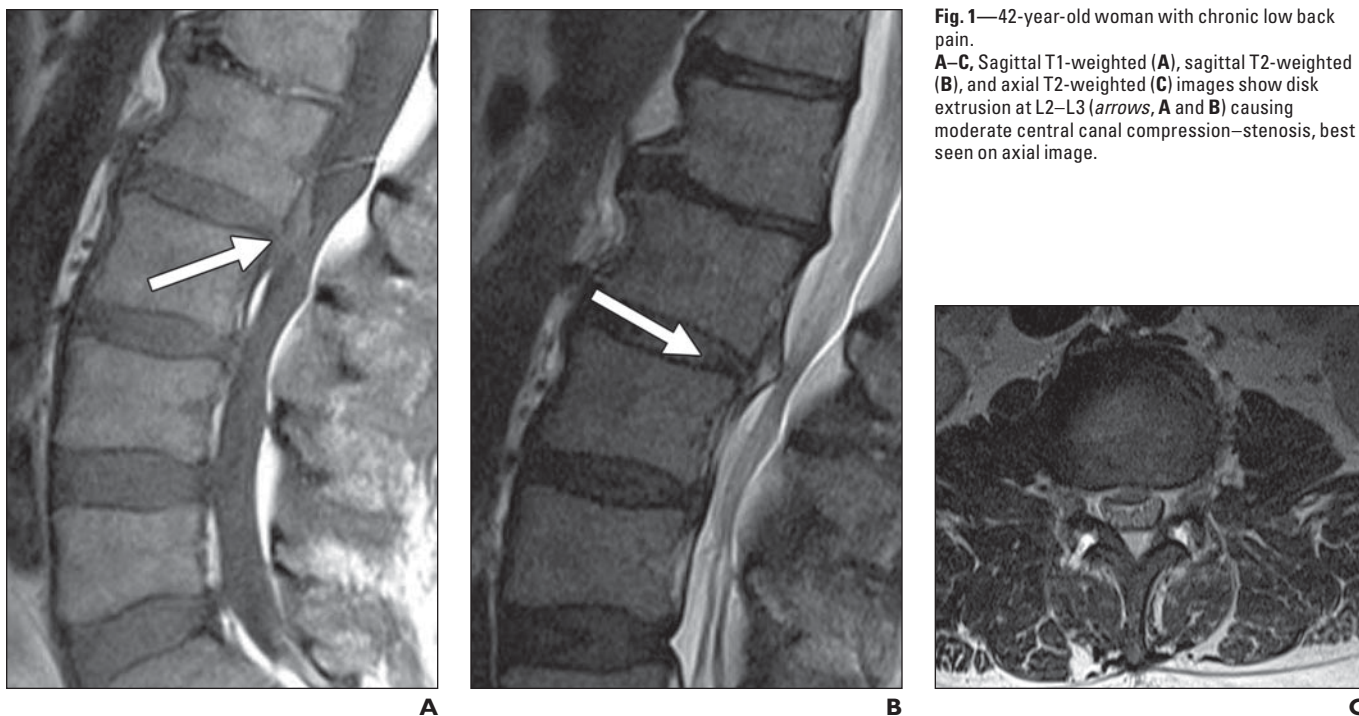


Fig. 1—42-year-old woman with chronic low back pain. **A–C**, Sagittal T1-weighted (**A**), sagittal T2-weighted (**B**), and axial T2-weighted (**C**) images show disk extrusion at L2–L3 (arrows, **A** and **B**) causing moderate central canal compression–stenosis, best seen on axial image.

Background and Importance

Low back pain (LBP) is one of the most common causes of physician visits in the United States [1], with a huge socioeconomic burden. In 2005, just the direct medical costs of care for LBP exceeded \$86 billion [2]. Because of this burden, numerous studies have focused on the diagnosis and management of LBP. New technologies have been quickly adopted with the hope that they will improve our understanding of the physiopathology of the disease and assist us in managing patients' pain and discomfort. Unfortunately, previous studies have not been able to show that higher utilization of advanced imaging technology is associated with improvements in patient outcome [3, 4].

The rationale for advanced imaging is frequently to identify rare but high-consequence conditions, such as metastases or infection. However, in the primary care population, fewer than 1% of all LBP patients have these conditions [5]. Therefore, the question remains how best to balance the high cost of procedures such as CT and MRI with their limited value in diagnosis and treatment of LBP patients.

Figure 2 summarizes the results of the most recent evidence-based LBP guidelines [6–10]. Without red flags in the history or physical examination, conservative care with patient education is the first step in pain

management. The focus of this article is to further explore the appropriate use of MRI in the management of patients with LBP.

The Imaging Question

Why is MRI not used as the routine initial test for patients with LBP? Related questions concern which patients should get MRI without radiography and the importance of the spinal stenosis and disk protrusion identified on the MRI. With its high contrast and spatial resolution and lack of ionizing radiation, MRI is considered by many to be the best imaging technique for the investigation of LBP [7]. Yet MRI also has limitations and drawbacks. We review these next.

Several randomized clinical trials have shown that among patients without red flags—clinical signs and symptoms indicating serious underlying conditions (Tables 1 and 2)—early imaging (vs conservative treatment without imaging) does not improve patient outcomes [3, 8, 11–18].

MRI is expensive. A frequent motivation for obtaining imaging in the primary care setting is to exclude an underlying malignancy as the cause of LBP. Joines and colleagues [19] compared the cost-effectiveness of MRI compared with a conventional cancer screening program using history, physical examination, erythrocyte sedimentation rate, and radiography for detecting spine ma-

lignancies among patients seen in a primary care clinic. They reported that MRI cost 10 times as much as the conventional strategy (\$50,000 vs \$5,000), and the cost of finding each extra patient with a spine malignancy in MRI group exceeded \$625,000 [19].

Another problem with MRI is the high prevalence of abnormal findings among individuals without LBP [20–34]. This high prevalence makes it difficult, or possibly even perilous, to attribute a patient's symptoms to certain imaging findings. Moreover, irrelevant findings can result in emotional stress, utilization of unnecessary downstream resources and even unnecessary interventions, such as surgery. Deyo and colleagues [35] showed a higher rate of spinal surgeries for LBP in states with a higher utilization rate of advanced imaging technology. However, this higher utilization rate was not associated with better patient outcome in these states [35].

Synopsis and Synthesis of Evidence

We have summarized the value of MRI for patients with LBP with various spine conditions.

Nonspecific or Idiopathic LBP

Approximately 70% of acute LBP patients can attribute their pain to spinal muscle strain or sprain [5]. These patients are, in general, younger and have no clinical red flags. Under these

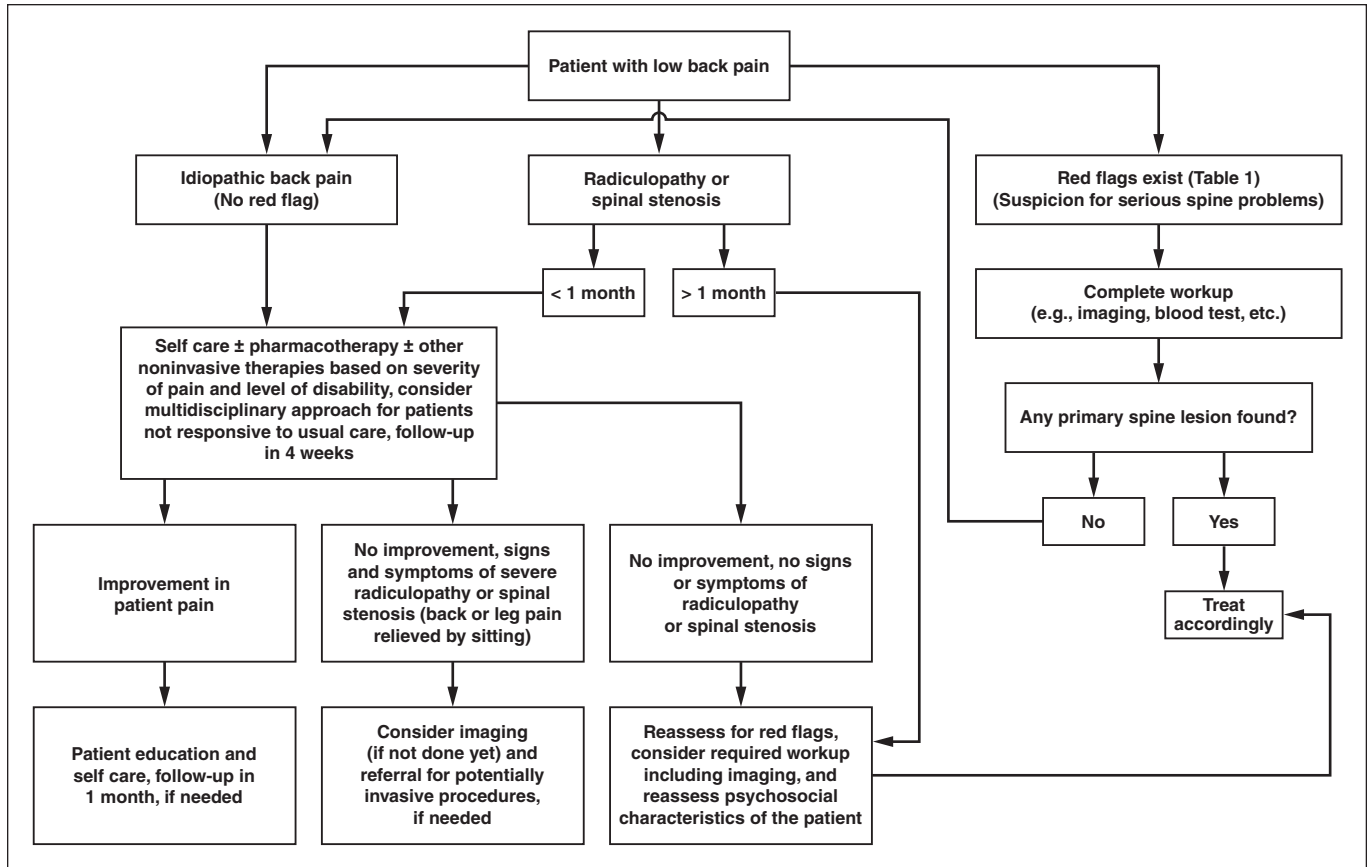


Fig. 2—Flowchart shows clinical practice guideline for management of low back pain [7].

circumstances, MRI should not be performed within the first 4–8 weeks of symptoms.

Disk Degeneration: Herniation, Bulges, Protrusions, and Extrusions

The Combined Task Forces of the North American Spine Society, American Society of Spine Radiology, and American Society of Neuroradiology have defined herniated disk as a “localized displacement of nucleus, cartilage, fragmented apophyseal bone, or fragmented annular tissue beyond the intervertebral disc space” [36]. A bulging disk is not considered a herniated disk and is defined as the presence of disk tissue diffusely (> 50% of the circumference) extending beyond the edges of the ring apophyses. This bulging can be symmetric or asymmetric [36] (Fig. 3).

Herniations are subdivided into protrusion and extrusions. As defined by the Combined Task Forces, a “protrusion is present if the greatest distance in any plane between the edges of the disc material beyond the disc space is less than the distance between the

edges of the base in the same plane.” If in any plane the greatest distance between the edges of the disk goes beyond the distance between the edges of the base, the lesion is called “extrusion” [36] (Fig. 3). In practical terms, if the herniated disk material has a neck, it is an extrusion.

T1- and T2-weighted sagittal and axial MR images can clearly visualize the vertebral endplates and intervertebral disks [37].

T2-weighted images show good contrast between the outer part of the annulus, which is more fibrous tissue (low signal), and inner part of the annulus and nucleus pulposus, which have more water content (high signal) [38]. An area of low-intensity signal may be visible in the middle of the nucleus pulposus in a nondegenerated disk [37, 38]. This is considered a normal observation and most commonly is visible in younger individuals.

TABLE I: Key Features in History and Physical Examination of Patients With Low Back Pain (LBP)

| Underlying Cause | Key Features in History | Possible Findings in Physical Examination |
|------------------|---|---|
| Idiopathic | Usually none; sometimes attributed to trauma | Vague spinal pain with or without paraspinal muscle spasm |
| Extruded disk | Radicular pain, usually in distribution of L4, L5, or S1 nerve root | Positive straight leg raise test; problem in walking on the heel (L4–L5 disk herniation) or on the toes (L5–S1 disk herniation) |
| Spinal stenosis | LBP or radicular pain that increases with walking and improves with seating and flexion of the spine in older individuals | Numbness, vibration deficit, abnormal Romberg test |

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TABLE 2: Potential Red Flags in History and Physical Examination of Patients with Low Back Pain

| Underlying Cause | Key Features in History | Possible Findings in Physical Examination |
|-------------------------------|---|---|
| Possible malignancy | Older adults, gradual increase in pain, history of cancer, unintentional weight loss, no relief with bed rest or conservative therapy, > 1 mo of pain | Cachectic appearance; signs and symptoms related to the underlying malignancy |
| Possible infection | History of IV drug use; recent immigration to the United States (especially a major risk factor for tuberculosis or Pott disease); history of urinary tract or skin infection | Fever, malaise, spinal tenderness to percussion |
| Possible compression fracture | Older adults, women, osteoporotic, often history of mild trauma or no history of trauma | Local pain on the fracture site |
| Cauda equina syndrome | Bladder dysfunction (usually urinary retention or overflow incontinence) with leg pain and weakness | Saddle anesthesia |
| Ankylosing spondylitis | Younger age, morning stiffness, improvement of pain with exercise, pain > 3 mo, pain not relieved in supine position | Restriction in chest expansion, limited spine movement |

It probably represents a higher concentration of proteoglycans causing signal loss on T2-weighted images [37, 38].

Intervertebral disks likely degenerate because of reduction in oxygen and nutrient supply due to the normal aging process, trauma, and so on [37, 39, 40]. Vertebral endplates play a key role in providing the nutrients to intervertebral disks. As a result, it is conceivable that changes in endplates occur at the same time or even before disk degeneration. Modic et al. [41] described three types of endplate changes. Type 1 is low signal on T1-weighted images and high signal on T2-weighted images and likely represents endplate edema. Type 2 is high signal on T1-weighted images and on T2 fast spin-echo images but is dark on fat-suppressed sequences and likely represents fat. Type 3 is low signal on both T1- and T2-weighted sequences and represents endplate sclerosis. These endplate changes are commonly referred to as “Modic” changes [41]. Some researchers have suggested that type 1 endplate changes are painful [42, 43]. For example, Kuisma and colleagues [43] reported significant association between Modic type 1 changes and the frequency and intensity of LBP among 228 middle-age Finnish workers. However, some other studies dispute these findings. In a study by Mitra and Harlin [44], 44 patients with 48 Modic type 1 changes were followed for 12–72 months. These authors were not able to detect any statistically significant association between Modic type 1 changes and patients’ symptoms.

MRI is the method of choice for the evaluation of disk morphology [7] because of the good sensitivity (60–100%) and specificity (43–97%) for disk herniations (both protrusions and extrusion) [10]. In this case, a positive test was the presence of either a protrusion or extrusion with the reference standard usu-

ally consisting of an expert consensus panel using an amalgam of various data depending on availability, including clinical information, other diagnostic testing such as myelography, and surgical findings [10]. The lower specificity of MRI can be attributed to the high prevalence of degeneration (46–93%) and protrusions (20–80%) in asymptomatic adults [45]. The wide range of prevalence may be partially explained by differences in age groups and definition of herniation.

Several studies have attempted to evaluate the correlation between MRI findings and symptoms. Porchet and colleagues [46] re-

ported a significant association between leg pain (not back pain) measured by a visual analog scale (VAS) and abnormal MRI findings. VAS is a psychometric tool that measures subjective characteristics that cannot be directly evaluated or measured [47]. In the study by Porchet et al., each additional centimeter on the VAS scale was associated with 10% lower odds of observing severe disk degeneration. In spite of this, studies often were not able to identify any MRI abnormality associated with pain for most LBP patients [31].

It has been suggested that disk morphology is associated with symptoms and as a result

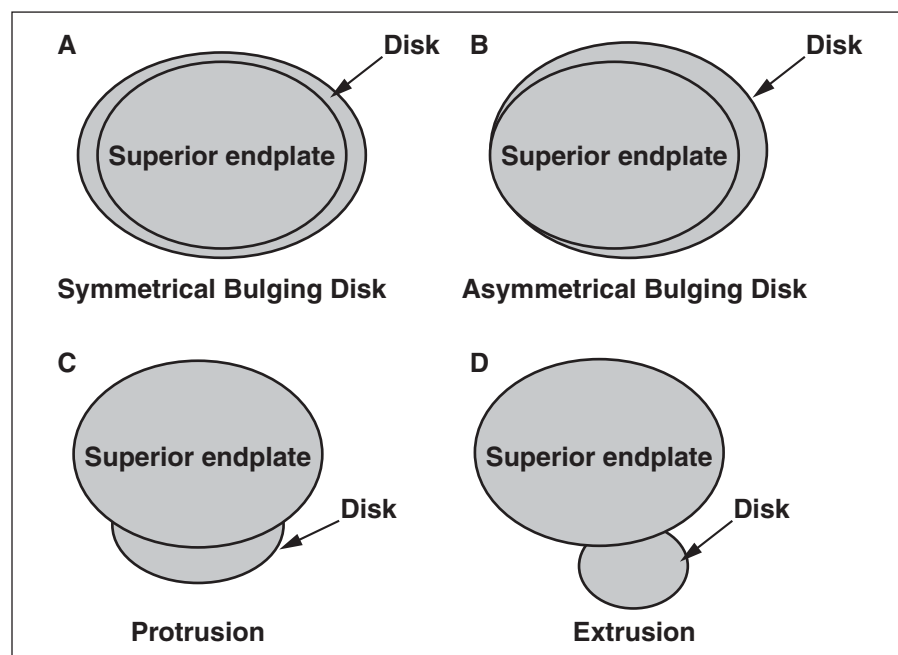


Fig. 3—Schematic shows different disk morphologies [36].

- A,** Symmetric bulging disk.
- B,** Asymmetric bulging disk.
- C,** Protrusion.
- D,** Extrusion.

should influence pain management [48, 49]. Although bulging disks and protrusions are common and poorly correlated with symptoms, extrusions are rare in asymptomatic patients (1–5% prevalence) and may be a good predictor of response to treatment and patient outcome [10].

Central Canal Stenosis

Spinal stenosis can occur for various reasons, such as congenital spine abnormalities and disk herniation, but classically consists of the triad of disk bulge with facet hypertrophy and hypertrophy of the ligamentum flavum. In general, MRI is considered the best approach for the workup of spinal stenosis [50–52]. The reported sensitivity and specificity of MRI for the diagnosis of spinal stenosis varies from 77% to 90% and 72% to 100%, respectively, with the reference standard in these studies consisting of either surgical findings or adequate clinical follow-up [51, 53–55].

T1-weighted images can clearly visualize stenosis and provide valid information regarding the underlying cause of stenosis [56]. In the case of spondylolisthesis, spinal stenosis is better visualized on sagittal T1-weighted images [38]. Long-term spinal stenosis at the level of the conus can result in myelopathy. This generally results in high intramedullary signal intensity on T2-weighted images that may enhance with gadolinium [56].

Because pain often is worse in the loaded spine or in certain positions such as flexion [57, 58], it is plausible that supine MRI would be less sensitive than upright MRI. In dynamic MRI, patients are usually positioned upright or in flexion or extension status to mimic those circumstances in which the spinal canal has the least diameter and, as a result, impose the most amount of pressure on spinal nerves [58]. Alyas and colleagues [58] used upright MRI and reported smaller central canal sizes when the spine was loaded. However, no rigorous study has evaluated the accuracy of upright and dynamic MRI. In addition, there is no evidence that the use of such technology improves patient outcome.

Infection

MRI is the method of choice for evaluation of spinal infections [59–61], with sensitivity of 96% and specificity of 92%, using final clinical, histologic, and microbiologic information as the reference standard [62]. Fat suppression and gadolinium administration are important techniques to use [59–61].

MRI allows physicians to diagnose infection early before bone destruction becomes visible on radiographs or even CT. Because MRI shows the extent of the disease and soft-tissue involvement, especially epidural extent, it is considered critical before surgical intervention [63].

The vertebral inflammation and edema in early stages of the disease are identifiable as low-intensity signal on T1-weighted and high-intensity signal on T2-weighted fat-suppressed images [38, 61]. In more advanced stages of the disease, fibrosis and sclerosis lead to lower signal and fatty changes of vertebral body and thus higher intensity signal on T1-weighted images [64].

Contrast-enhanced MRI improves detection of intravertebral, paravertebral, and epidural abscesses [61] by enhancing the margin of the abscess, whereas the central portion of abscess remains unenhanced. This increased conspicuity is especially important with epidural extension [65]. In spite of the anecdotal importance of contrast-enhanced MRI, no study has evaluated the value of contrast administration with respect to patient outcomes in the diagnosis and management of spinal infection.

MRI has a few limitations in the evaluation of spinal infections. First, in a fully developed infection, two adjacent vertebrae and the intervening disk are usually involved. However, in the early stages of disease, involvement of both vertebrae might not be visible [64]. Second, surgical interventions can distort the normal spinal anatomy, making it difficult to interpret postsurgical images [59]. Finally, there is limited evidence regarding the value of follow-up MRI of patients with spinal infection [59].

In spite of successful treatment, MRI findings often lag, showing a worsening appearance for several weeks or months [65]. Probably the most valuable imaging findings to monitor treatment are decreasing bone marrow edema and decreasing contrast uptake [65].

Ankylosing Spondylitis

Although radiography remains the initial imaging technique for patients with ankylosing spondylitis, MRI is the method of choice for subsequent evaluations of the spine [66–68], with sensitivity of 25–85% and specificity of 90–100% using a combination of clinical, laboratory, and follow-up of up to 1 year as the index standard [63]. Spinal inflammation is more visible at the corners of vertebral bodies (which lead to Romanus lesions) or endplates, although spinous processes

and facet joints might also become involved [69]. Similar to other causes of inflammation, ankylosing spondylitis leads to low-intensity signals on T1-weighted and high-intensity signals on STIR or fat-suppressed T2-weighted images [67].

MRI has also been used in evaluation of the response to antitumor necrosis factor therapy [67]. However, in spite of the widespread use of MRI in the management of inflammatory spine diseases, no robust study has evaluated the value of MRI in the management of spondyloarthropathies [67].

Metastases

MRI is the best approach for evaluation of spine metastases because its high soft-tissue contrast results in excellent sensitivity [70–75]. The reported sensitivity of MRI varies from 83% to 100% and the estimated specificity is 92%, using biopsy or clinical follow-up as the index standard [71–74, 76].

Spinal metastases can be intramedullary, extramedullary–intradural, or extradural. T2-weighted MR images show intramedullary lesions as areas with high-intensity signals that enhance with contrast administration [38]. T1-weighted images with contrast administration and fat-suppression can be used to visualize extramedullary–intradural or extradural metastasis.

Compression Fractures

Spinal compression fractures mostly occur in older women with osteoporosis, with or without any identifiable trauma. CT, especially MDCT, is the method of choice in the evaluation of bony structures. However, MRI is the best technique to investigate marrow edema and soft tissues, including spinal cord and ligaments [77–80].

Sagittal T1-weighted, T2*-weighted, and STIR sequences are usually used for diagnosis of traumatic injuries. MRI clearly depicts cord compression due to displaced bone or disk. MRI also clearly shows bone marrow edema, helping to identify which fractures are acute. Edema is better visible in the sagittal plane using fat-suppressed T2-weighted or STIR sequences [81].

Other potential findings that could indicate acute versus chronic fracture are paravertebral hemorrhage and spinal cord edema. These can be clearly visualized on T2-weighted MR images [77, 79].

Finally, MRI findings can be used to differentiate between malignant versus benign vertebral fractures. The presence of each one

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of the following findings could indicate spinal metastasis: vertebral body expansion with a convex posterior border, abnormal signal completely replacing normal marrow and extending into the posterior elements, and presence of a paraspinal mass [77]. In contrast, low-signal bands in the vertebral bodies on T1- and T2-weighted images, normal bone marrow appearance, and presence of several compression fractures are more in support of benign osteoporotic compression fractures [77, 82]. Zajick et al. [83] described the use of in-phase/out-of-phase imaging to distinguish benign from malignant fractures. They found that benign fractures had signal suppression of at least 20% on the out-of-phase compared with the in-phase images, whereas malignant fractures did not (sensitivity and specificity, 95%), using clinical criteria and other MRI sequences to establish the index standard of metastatic disease [83].

Although there are several published reports of newer MRI techniques, such as diffusion-weighted MRI (DWI) and MR spectroscopy (MRS) for distinguishing benign from malignant compression fractures [84–87], no published reports have shown the influence of these new techniques on patient outcome. For example, Baur and colleagues [86] used DWI to differentiate 22 benign from 17 malignant compression fractures. They found that benign compression fractures were hypo- to isointense relative to normal adjacent vertebra, whereas malignant lesions were hyperintense. However, the authors were not able to detect any statistically significant difference in bone marrow contrast ratios between benign and malignant lesions [86]. In a more recent study, Oztekin and colleagues [85] evaluated the validity of single-shot echo-planar DWI with a low b value for the same purpose. A total of 64 lesions (27 benign and 37 malignant) with low-intensity signal on T1-weighted images were investigated using the single-shot echo-planar DWI method. All malignant lesions (except two sclerotic metastases) showed hyperintense signals relative to normal bone marrow. Twenty-three of 27 benign lesions had isointense signals relative to adjacent normal bone marrow [85].

Evidence-Based Guidelines

In 1994, for the first time, the Agency for Health Care Policy and Research (AHCPR) published a set of guidelines to assist physicians in the management of LBP less than 3 months in duration [88]. Using an evidence-based medicine approach, Jarvik and Deyo

[10] revised the AHCPR guidelines and published an updated algorithm for the diagnostic evaluation of LBP. Later on, the European Commission, Research Directorate-General, Department of Policy, Coordination, and Strategy [6] and most recently the American College of Physicians and the American Pain Society published LBP management guidelines based on the most recent publications [7]. In spite of substantial advancements in technology during the past two decades, the main conclusions of all these guidelines are practically the same. All of the guidelines emphasize the importance of a focused history and thorough physical examination before any imaging is ordered. In addition, all agree that for patients with acute LBP and without any risk factor for serious spine abnormalities, imaging within the initial 4–8 weeks should not be performed.

Outstanding Issues That Warrant Research

Economic Analysis of New Imaging Techniques

Although new technologies have been quickly adopted for the management of LBP, limited attention has been paid to the cost-effectiveness of these new techniques [3, 19, 89]. This issue is of paramount importance, especially now that the health care system is expecting a substantial overhaul. The following might partially explain the scarcity of these studies.

First, to perform a cost-effectiveness analysis, researchers should be able to confidently estimate the effectiveness of an intervention (in this case, new imaging technology). Defining the effectiveness of a diagnostic test is less straightforward than a therapeutic intervention. Fryback and Thornbury [90] defined a hierarchic model of diagnostic test efficacy. Depending on the purpose of the evaluation, efficacy or effectiveness can be defined in terms of diagnostic accuracy, impact on diagnostic decision making, impact on therapeutic decision making, or patient outcome.

Unfortunately, studies that focus on the diagnostic accuracy of new lumbar spine imaging technologies often do not compare their findings with a reference standard. As a result, comparing different imaging techniques, and even different studies evaluating the same imaging technique, is often difficult. In addition, as noted earlier, researchers frequently use different outcomes, which makes the comparison even more cumbersome.

The second hurdle is the lack of robust financial information. This includes the true

cost of the imaging test (e.g., cost of MRI without contrast administration), downstream costs related to the diagnostic test, and the monetary or nonmonetary value of the outcomes of interest (e.g., the monetary value of reducing the length of hospital stay).

To these methodologic challenges, we add potential problems regarding assessment of new technologies by the Food and Drug Administration (FDA) [91–95]. The FDA is responsible for both safety and effectiveness of new technologies, including imaging devices. However, conducting well-designed, controlled trials that evaluate the effectiveness of these diagnostic interventions requires large numbers of patients, often using multiple institutions. An ongoing challenge is the moving-target problem: by the time the study is finished, the evaluated technology is replaced either with a new generation of the same technology or with a more advanced technique [95]. Because of the size of the industry and rapidly evolving new technologies, the FDA has mainly focused on safety, adopting an engineering approach rather than also considering the broader effectiveness of the new techniques and not at all addressing costs [95]. In addition, the FDA categorizes most imaging techniques as low-risk technologies (class I or II) that are not associated with significant risks for human beings [94, 95]. As a result of this classification, companies are not required to provide intense premarket evidence regarding the effectiveness of their products. This issue leads to a lack of incentive for the conduction of robust, controlled effectiveness evaluations [95].

Many believe that the coverage of new imaging techniques by payers is the best motivation for performing cost-effective analysis [93]. However, insurance companies might or might not use this sort of information. For example, the Centers for Medicare and Medicaid Services (CMS) does not and cannot use cost-effectiveness information in its coverage decisions of new technologies [93]. Although other payers are not similarly constrained, as the largest payer in the United States, where CMS leads, others follow [95].

Other MRI-Based Imaging Techniques That Require Further Research

MR spectroscopy—Although MRI exquisitely shows tissue anatomy, MRS is a non-invasive tool that evaluates function by measuring the level of various tissue metabolites [96–102]. MRS has been extensively used for the diagnosis of brain tumors [96, 97, 100,

102, 103]. However, recently its use has been expanded to other health conditions, such as prostate and breast malignancies, multiple sclerosis, epilepsy, and even traumatic brain injuries [96, 99, 102]. Although no study has rigorously investigated the potential role of MRS in LBP management, some exploratory studies have been conducted, looking at disk degeneration [104] and marrow fat content as a risk factor for fracture [105] and the evaluation of possible metastasis [106]. It is conceivable that MRS could be a valuable tool, but this technique should be considered exploratory for the time being.

Diffusion-weighted MRI—DWI is another noninvasive MRI-based technique that was first developed for the diagnosis of acute brain ischemia [107–110]. In this approach, microscopic and random movements of water molecules within tissues are used to create images with very high tissue contrast [107–109].

Recently, DWI has been adopted for detection of different musculoskeletal abnormalities [107]. DWI can be used for the evaluation of the response to treatment in tumors, such as osteosarcoma, that in general do not shrink in response to treatment. Under these circumstances, detection of necrosis with DWI within the tumor may be a valid indicator of response to treatment and is associated with better outcome [111]. The decrease in DWI signal of a tumor is another indicator that treatment has been effective. This can be seen in primary bone sarcomas and also spine metastasis [112, 113].

As mentioned previously, DWI also has been used to differentiate between benign and malignant vertebral fractures [86, 114, 115], although this process can become challenging because of factors such as the spine motion and other associated artifacts [107]. Another potential use of DWI is the assessment of intervertebral disks [116–119]. Further studies are required to evaluate the sensitivity and specificity of DWI in the diagnosis of different LBP causes.

MR neurography—MR neurography provides information on the anatomy of peripheral nerves [120–122]. This information can be used for identification of small nerve tumors that are not detectable with other techniques. In case of nerve injury, MR neurography could show if the continuity of a nerve is threatened. The presence of edema in the nerve is a robust finding that indicates the nerve is under compression by surrounding tissues. Because of these reliable findings, a

few studies have compared MR neurography with nerve electrodiagnostic studies [123–126]. These studies have shown that MR neurography has a comparable sensitivity and specificity with electrodiagnostic studies in the diagnosis of ulnar and median nerve entrapment [123, 124].

MR neurography has also been used in evaluation of non-disc-related sciatica. Especially among those who do not respond to surgical interventions, visualization of the nerve by MR neurography can provide valuable information regarding the factors that might have resulted in surgery failure. As a result, MR neurography may have an adjunctive role to electrodiagnostic testing [127].

In spite of the potentially valuable information that MR neurography can provide, there is limited information on the validity of this method in LBP management. Similar to most other MRI-based investigations, studies suffer from lack of comparison with a current reference standard for diagnosis. More important, the associations between abnormal findings and signs and symptoms have not been well established.

Summary

MRI and other MRI-based imaging techniques provide valuable information regarding the underlying causes of LBP. However, because of several factors that have been addressed in this article, utilization should be limited to those patients who are most likely to benefit from these tests. In addition, to be able to evaluate the effectiveness and efficiency [128] of new imaging technologies, clinicians and researchers should be encouraged to follow standardized practices that are in accordance with evidence-based medicine guidelines [129]. The use of such guidelines will decrease variation in care, allowing researchers to more easily design and conduct comparative effectiveness studies of diagnostic imaging.

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